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RAILWAY CURVES

BY

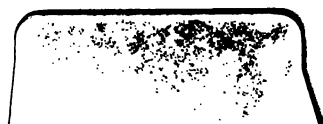
JOHN LEAN, C.E.,

ASSOC. INST. C.E.

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# Railway Curves :

A COMPLETE, PRACTICAL, AND EASY SYSTEM OF

## SETTING OUT RAILWAY CURVES

WITH ACCURACY AND DISPATCH;

INCLUDING FORMULÆ FOR CALCULATING ANGLES OF

INTERSECTIONS FOR PERMANENT-WAY FITTINGS,

AND

Setting out Switches and Crossings;

WITH EXAMPLES FOR WORKING EACH FORMULÆ.

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By *JOHN LEAN, C.E., Assoc. Inst. C.E.*

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LONDON: W. KENT & CO., PATERNOSTER ROW.  
NEATH: W. WHITTINGTON, POST OFFICE, WIND STREET.

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## Advertisement.

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*These Rules and Formulæ will be found sufficient to enable the Practical Engineer to meet every case that may arise, with ease and accuracy. They were originally compiled and arranged for the use of my own Staff; but being persuaded that, published in this form, they may be of service to the Practical Engineer, as well as to the Student, I now offer them to their notice.*

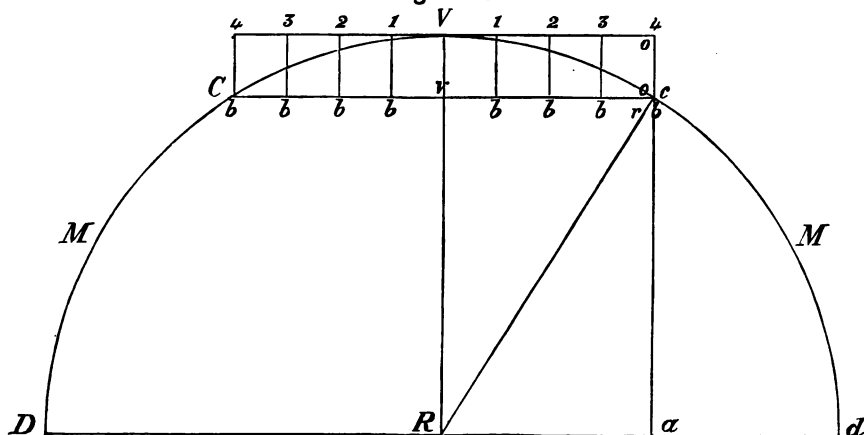
*J. L.*



# SETTING OUT RAILWAY CURVES.

Properties of the circle applicable to setting out Railway Curves :—  
*D d* diameter; *R r* radius; *M M* circumference; *C c* chord; *V v* versed sine;  
*T* tangent.

Figure 1.



- 1.— $\frac{D d}{2} = R$ .
- 2.— $D d \times 3.1416 = M M$ .
- 3.— $\sqrt{R r^2 - V C^2} = R V$ .
- 4.— $R - R V = V V$  or  $O O$ .
- 5.— $R - \sqrt{R^2 - r V^2} = V V$ .
- 6.— $\sqrt{D a \times a d} = A O$ . Then  $R - a O = O O$  or  $V V$ .
- 7.—The offsets 1, 2, 3, &c., are equal to the squares of their distances on the tangent line.
- 8.—The ordinates  $b b$ , &c., are equal to  $V V - 1^2 2^2 3^2$  &c.; or  
 Approximate for chords not more than  $\frac{1}{3}$  the radius.
- 9.—Divide  $V V$  into twice the number of parts contained in  $C c$ . Any ordinate  $b 1$ ,  $b 2$ ,  $b 3$ , &c., is equal to as many of these parts as the product of the parts  $b C \times b c$ .
- 10.— $\frac{T^2}{2 R} = \text{offset}$ .
- 11.— $\frac{1}{2} \sqrt{\frac{V C^2}{V}} + V V = R$ .

# Section 1.—The Theodolite.

## SETTING OUT RAILWAY CURVES.

- 1.—The Theodolite may be used in two ways for ranging curves:—  
1st: Running a straight line, thus:—

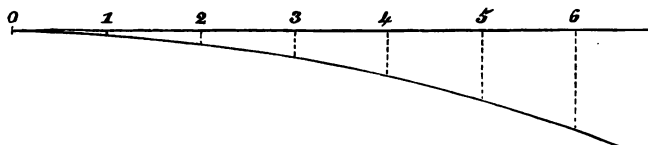


Figure 2.

From which a curve may be set off by offsets, as 1 2 3, &c.; or,

- 2.—2nd: By running chain tangents, thus:—

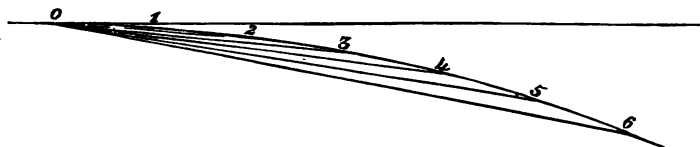


Figure 3.

3.—In either case, set the instrument to the tangent line, and, in using the Theodolite, frequently turn the instrument on to the tangent point, to make sure it has not shifted, and do not set out more than 10 chains without removing the position of the instrument.

### FORMULÆ.

4.—Divide 5400, the number of minutes in a quadrant, by 3·1416, which will produce the constant, 1719. This constant, divided by the number of chains in the radius, will give the offset in minutes of the circle for one chain tangent.

### EXAMPLE.

- 5.—Required the offset for 1 chain tangent, radius being 20 chains:—

$$\frac{1719}{20} = 20)1719(85\cdot87 = 1^{\circ}25'57''$$

1719
20
160
119
100
19
60
1140
100
140
140

*Add this offset for every additional chain of tangent.*

6.—Or  $\frac{T \times 3.1416}{180} = O$  in degrees of the circle.

Here T is the number of times the tangent is contained in the diameter of the curve. O = offset.

EXAMPLE.

7.—Required the offset in degrees of the circle for a curve of 20 chains radius, the tangent being 1 chain.

Here T is contained 40 times in the diameter.

Then	3.1416	
	40	
	125.6640	180.0000(1° 25' 57"
	125.6640	
	.54.3360	
	60	
	125.6640	32601600(25
	2513280	
	7468800	
	6283200	
	1185600	
	60	
	125.6640	71136000(56
	6283200	
	.8340400	
	7539840	
	764160	

8.—In every alteration of the curve, or in setting out a reverse curve, with the Theodolite, the best way is to fix the instrument on a tangent to the point of reversal, or alteration, and proceed as before.

(See Figures 2 & 3.)

## Section 2.

### SETTING OUT CURVES WITH POLES.

9.—1st method.—In ranging curves with poles, where practicable, run a long tangent, thus:—

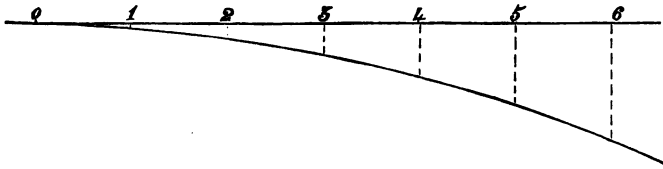


Figure 4.

Setting out the curve by offsets, as 1 2 3 4, &c., but in no case let the tangent exceed  $\frac{1}{3}$  of the radius.

10.—2nd method.—Run the tangent on, putting up a pole at 1 chain on the tangent line, and shifting it by the offset to 1a, then run a line from O through 1a on to 2, then put the pole at 2a by the proper offset, noting that the 2nd and each succeeding offset will be twice the first offset.

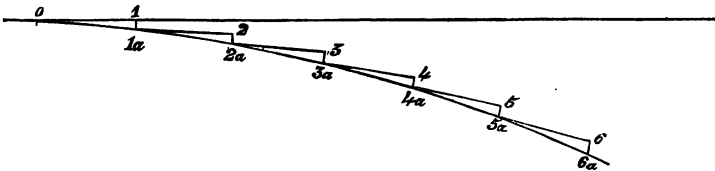


Figure 5.

11.—Offsets are to each other, as the square of the length of the tangent.

12.—Accurate method of calculating offsets, in measurements for any length of tangent. (See Figure 6.)

$$R - \sqrt{R^2 - T^2} = O$$

T T Tangent.

R r Radius.

O O Offset.

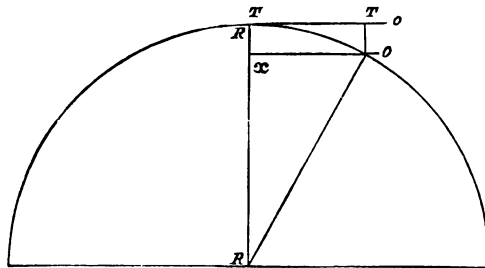


Figure 6.

## EXAMPLE.

13.—Required the offset for 1 chain tangent, the radius being 20 chains.

TT = 66	RR = 20 chains = 1320
66	1320
<u>396</u>	<u>26400</u>
396	3960
<u>4356</u>	<u>1320</u>
	<u>1742400</u>
	4356
	1320·00 radius.
	/ 1.73.80.44(1318·34
	1
	1·66 offset required.
	23)73
	69
	<u>261)480</u>
	261
	<u>2628)21944</u>
	21024
	<u>26363)92000</u>
	79089
	<u>263664)1291100</u>
	1054656
	<u>236444</u>

14.—Or, divide the semicircle A D (*See Figure 7*) by ordinates, as A B, B C, B C, &c.

Then  $\sqrt{A B \times B D} = B C$  and  $R - B C = \text{offset from tangent.}$

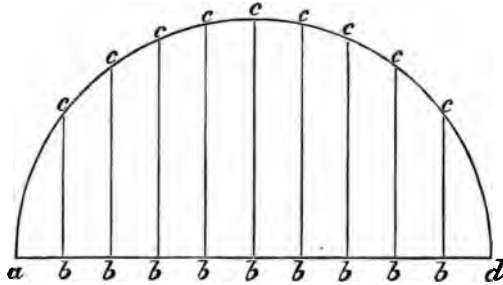


Figure 7.

EXAMPLE.

15.—Required the offset for 1 chain tangent, the radius being 20 chains. Take any distance with its complement, as 19 chains, 21 chains.

A B = 19 chains = 1254 feet.

1254

B D = 21 „ = 1386 „

1386

7524

10032

3762

1254

1320.00 radius

/ 1.73.80.44 (1318.34 ordinate.

1.66 offset from tangent.

23)73

69

261)480

261

2628)21944

21024

26363)92000

79089

263664)1291100

1054656

236444

16.—To connect two lines, EA, CF, by curve AIC. (*See Figure 8.*) Produce the lines EA and FC to an angle at B; then measure the bisecting line AC, and the perpendicular DB, making BA and BC equal. Then  $BD : DC :: BC : CI$ .

$$\text{Thus } \frac{DC}{BD} = X \frac{R}{X} = BF \text{ or } EB.$$

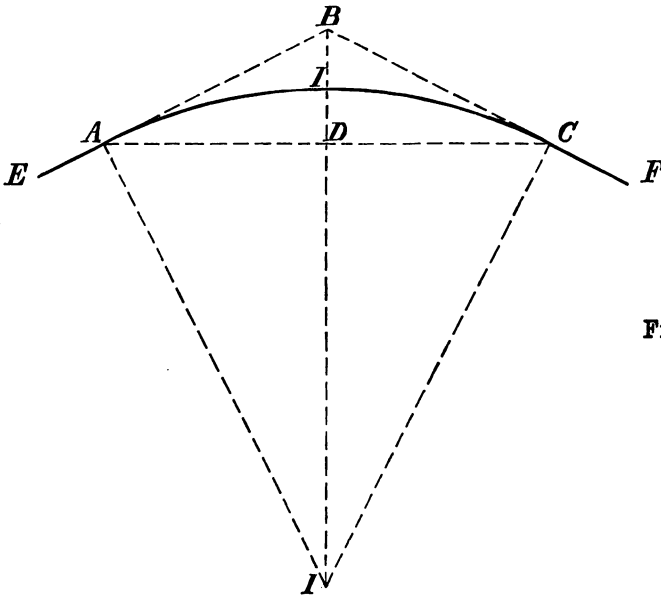


Figure 8.

EXAMPLE.

17.—Required to construct a curve 1000 feet radius in the triangle ABC. Suppose  $BD = 6$  and  $CD = 30$ , F and E being points from which the curve will start.

$$\begin{array}{r} 6)30(5)1000 \text{ radius.} \\ \underline{30} \quad \underline{200} = BF \text{ or } EB. \\ \hline \end{array}$$

18.—Or, to connect two lines, AF and GD, by a curve FIG. (*See Fig. 9.*) Produce the lines AF and GD to an angle at B, and if the angle be more than 140 degrees, produce the base line FG, making FB and BG equal; then make BI and CI equal, and I is a point in the curve.

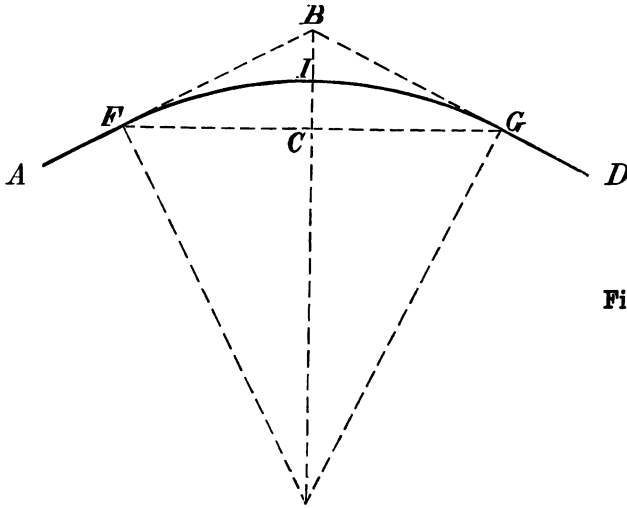


Figure 9.

19.—If the curve required be of any given radius, then produce any curve at random, as FIG, and as the curve produced is to the radius of curve required, so is BG and BF to the distance required for starting the curve on the line BA and BD.

## EXAMPLE.

20.—Let it be required to connect the lines AF and GD by a curve of 1000 radius. Produce the curve FIG at random, supposing  $FG = 200'$ ,  $BC = 20'$ , and  $IC = 10$ ; then BG and BF will equal  $= 102'$ , and the radius of the curve produced will be  $500'$ .

$$\text{Then } \frac{1,000 \text{ radius required.}}{500 \text{ radius produced.}} = 2.$$

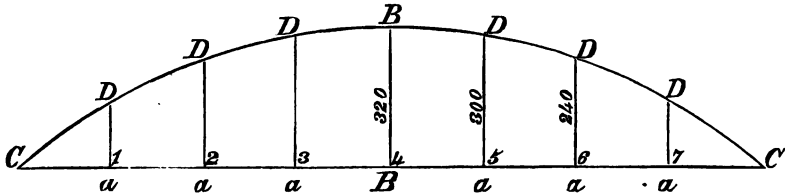
And  $102' \times 2 = 204$ , the distance required on the lines AB, BD for commencing the curve of 1000 radius.

# SETTING OUT CURVES FROM THE CHORD LINE

21.—Calculate in the usual way the versed sine, B B, and divide this versed sine into the same number of parts as the chord C c.

$$\text{Then } \frac{A C \times A c}{2} = A D.$$

Figure 10.



EXAMPLE.

22.—Let the chord Cc, 8 chains long, be divided by ordinates, as A D, A D, &c., into 8 aliquot parts. If the radius of the curve be 20 chains, then B B = 26·8.

$$\text{Then } B c \times B C = 4 \times 4 = \frac{16}{2} = 8 \frac{26 \cdot 8}{8} = 3' \cdot 4''.$$

$$,, \quad C a 5 \times c a 3 = \frac{15}{2} = 7 \cdot 5 \times 3' \cdot 4'' = 25'.$$

$$,, \quad C a 6 \times c a 2 = \frac{12}{2} = 6 \times 3' \cdot 4'' = 20'.$$

$$,, \quad C a 7 \times c a 1 = \frac{7}{2} = 3 \cdot 5 \times 3' \cdot 4'' = 11' \cdot 8''.$$

And so for the other side.

The following are easy approximate methods for calculating offsets.

FORMULÆ.

23.—The number of times the expression of measurement is contained in the tangent, divided by the number of times the tangent is contained in the diameter, will give the offset.

EXAMPLE.

24.—Required the offset of 1 chain tangent, radius being 20 chains.

1 chain, 100 links

$$\text{Then } \frac{100}{40} \text{ chains} = \text{offset } 40 \frac{100}{80} (2 \cdot 5 = \text{offset}.$$

$$\begin{array}{r} 80 \\ 200 \\ 200 \\ \hline \end{array}$$

25.—Or, one divided by the number of times the tangent is contained in the diameter, will give the offsets in decimals of the tangent.

## EXAMPLE.

26.—Required the offset for 1 chain tangent, radius being 20 chains.

$$\begin{array}{r} \text{Then } 20 \times 2 = 40 \quad 40)1.00(.025 = \text{offset.} \\ \underline{80} \\ 200 \end{array}$$

27.—Or, if the tangent is in chains, and the offset required in inches, divide 792 by the number of chains contained in the diameter.

28.—Required the offset for one chain tangent, radius being 20 chains.

## EXAMPLE.

$$\begin{array}{r} 40)792(19''.8 = \text{offset.} \\ \underline{40} \\ 392 \\ \underline{360} \\ 320 \\ \underline{320} \\ 0 \end{array}$$

29.—For any length of tangent not exceeding  $\frac{1}{3}$  of radius,  $\frac{T^2}{D} = O$  that is tangent squared, divided by diameter, equal to offset.

## EXAMPLE.

30.—Required the offset for 1 chain tangent, radius being 20 chains.

$$\begin{array}{r} 20 \times 2 \times 66 = 2640) \quad 66 \\ \underline{66} \\ 396 \\ \underline{396} \\ 4356(1.65 \text{ offset.} \\ \underline{2640} \\ 17160 \\ \underline{15840} \\ 13200 \\ \underline{13200} \\ 0 \end{array}$$

SLIP OR CROSS-OVER ROAD.

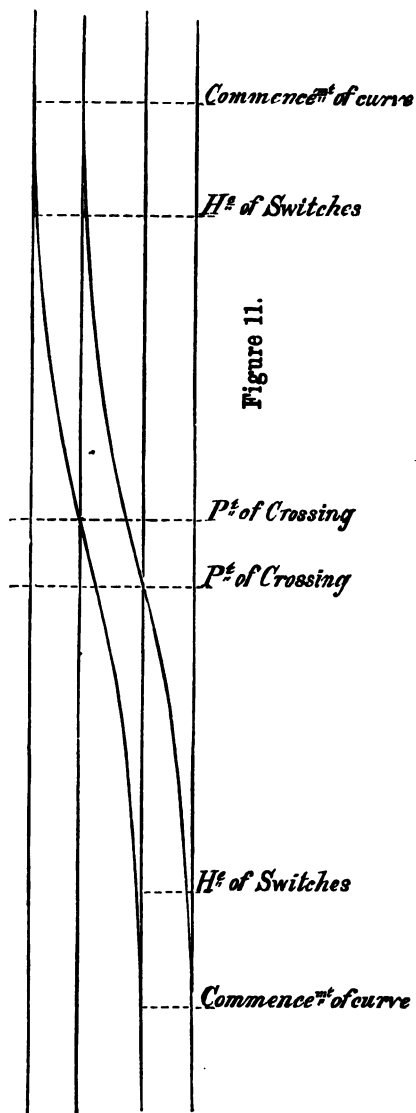


Figure 11.

## Section 3.

### PERMANENT WAY.

31.—To measure the ratio of intersection of crossings on the ground.



Figure 12.

Measure to where the face of rails diverge 6 inches from each other on each side of the point of crossing, then measure the distance between those points (as see diagram from A to B), which is the ratio of intersection.

32.—To calculate the ratio of angle of intersection of crossing.

A Gauge of road.  
R Radius of curve.  
I Angle of Intersection.

$$\frac{\sqrt{R}}{2a} = I.$$

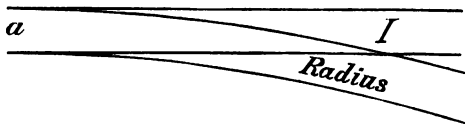


Figure 13.

#### EXAMPLE.

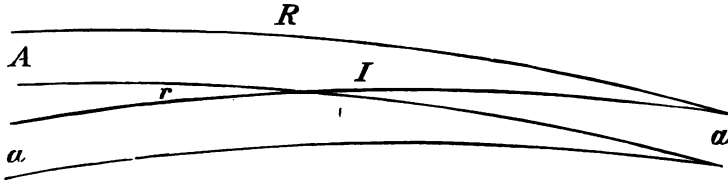
33.—Required the ratio of angle of intersection, gauge of road being 4·70, and radius of curve 600 feet.

Then 4·70  
2

$$\begin{array}{r} 9\cdot40 \overline{)600\cdot00} \\ \underline{564\ 0} \\ 3600 \\ \underline{2820} \\ 7800 \\ \underline{7520} \\ 2800 \\ \underline{1880} \\ 920 \end{array} \quad \begin{array}{r} / 63\cdot82 \\ \underline{49} \\ 1482 \\ \underline{1341} \\ 14100 \\ \underline{12704} \\ 1396 \\ \underline{\hspace{1cm}} \\ 920 \end{array} = I.$$

34.—To calculate the ratio of the angle of intersection when two roads approach each other of different radii.

Figure 14.



R r Radius.  
A Gauge of road.  
I Angle of intersection.

$$\text{ACCURATE } \sqrt{2} \left( \frac{R \times r}{R - r + \frac{1}{2} A} \right) A = I.$$

EXAMPLE.

35.—Required the ratio of the angle of intersection, gauge of road being 4.70, and radii being 1200 and 600 feet.

1200		
600		
<hr/> 600		
2.35		
<hr/> 602.35		
9.40		
<hr/> 2409400	1200	
542115	600	
<hr/> 5662.09	)720000(	/ 1.27.16(11.27 = I.
<hr/> <hr/> 566209	1	
1537910	21)27	
1132418	21	
<hr/> 4054920	222)616	
3963463	444	
<hr/> 914570	2247)17200	
566209	15729	
<hr/> 3483610	<hr/> 1471	
3397254		
<hr/> 86356		
<hr/> <hr/>		

36.—APPROXIMATE.  $\frac{R \times r}{\sqrt{2(R-r)}} A = I$

37.—EXAMPLE.

1200	1200
<u>600</u>	<u>600</u>
<u>720000</u>	<u>600</u>
	9.40
	<u>24000</u>
	5400
/ 1.27.65(11.29 = I.	5640. )720000(127.65
<u>1</u>	<u>5640</u>
21)27	<u>15600</u>
<u>21</u>	<u>11280</u>
222)665	<u>43200</u>
<u>444</u>	<u>39480</u>
2240)22100	<u>37200</u>
<u>19241</u>	<u>33840</u>
<u>2859</u>	<u>33600</u>
	<u>28200</u>
	<u>5400</u>

38.—To calculate the ratio of the angle of intersection when two curves leave one another.

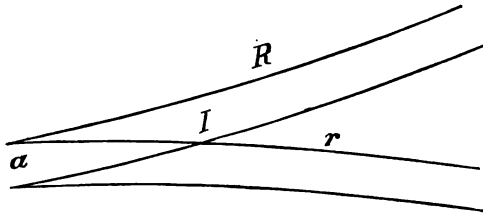


Figure 15.

ACCURATE.  $\frac{R \times r}{\sqrt{2(R+r-\frac{1}{2}A)}} A = I.$

## EXAMPLE.

39.—Required the ratio of the angle of intersection, gauge of road being 4.70, and radii of roads being 800 and 600 feet.

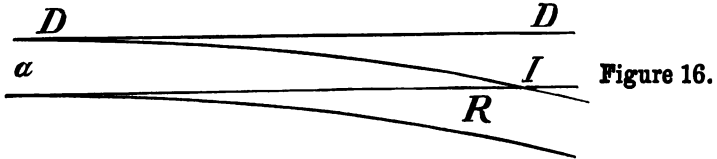
800	600
600	800
13237.91)480000.0(36.25	1400
3971373	2.35
8286270	1397.65
7942746	9.40
3435240	6590600
2647582	1257885
7776580	13237 9100
6618955	
1157625	Then 36.25(6.02 = I.
	36
	1202)2500
	2404
	96

40.—APPROXIMATE.  $\frac{R \times r}{\sqrt{2(R+r)A}}$ .

41.—EXAMPLE.

800	800
600	600
13160)480000(36.47	1400
39480	9.40
85200	56300
78960	12600
62400	13160.00
52640	
97600	Then 36.47(6.03 = I.
92120	36
5480	1203)4700
	3609
	1091

42.—To ascertain the point of ratio of intersection (*i.e.* point of crossing) from commencement of curve.



$$\sqrt{2R} - A \times A = D.$$

Here R is Radius.

„ A „ Gauge of road.

„ D D „ Distance from commencement of curve to point of crossing.

„ I „ Ratio of intersection.

**EXAMPLE—ACCURATE.**

43.—Required the distance from point of ratio of intersection to commencement of curve, radius being 600 feet, and gauge of road 4.70.

$$\begin{array}{r}
 600 \\
 2 \\
 \hline
 1200 \\
 4.70 \\
 \hline
 1195.30 \\
 470 \\
 \hline
 8367100 \\
 478120 \\
 \hline
 / 56.17.91.00(74.95 \\
 94 \\
 \hline
 144)717 \\
 576 \\
 \hline
 148.9)14191 \\
 13401 \\
 \hline
 14985)79000 \\
 74925 \\
 \hline
 4075 \\
 \hline
 \hline
 \end{array}$$

44.—**APPROXIMATE.**  $\sqrt{2R} \times A = D.$

45.—EXAMPLE.

$$\begin{array}{r} R \ 600 \\ 2 \\ \hline \end{array}$$

$$\begin{array}{r} 1200 \\ 4 \cdot 70 \\ \hline \end{array}$$

$$\begin{array}{r} 84000 \\ 4800 \\ \hline \end{array}$$

$$564000(75 \cdot 09 \text{ distance required.}$$

49

$$\begin{array}{r} 145 \overline{)740} \\ 725 \\ \hline \end{array}$$

$$\begin{array}{r} 15009 \overline{)150000} \\ 135081 \\ \hline \end{array}$$

$$\begin{array}{r} 14919 \\ \hline \hline \end{array}$$

46.—Or, APPROXIMATE.  $2 I \times A = D.$ 

47.—EXAMPLE.

$$\begin{array}{r} I = 7 \cdot 98 \\ 2 \\ \hline \end{array}$$

$$\begin{array}{r} 1596 \\ 4 \cdot 70 \\ \hline \end{array}$$

$$\begin{array}{r} 111720 \\ 6384 \\ \hline \end{array}$$

$$75 \cdot 01 \cdot 20 \text{ distance required.}$$

48.—Or, APPROXIMATE.  $\frac{R}{I} = D.$ 

49.—EXAMPLE.

$$7 \cdot 98 \overline{)600 \cdot 00} (75 \cdot 18 = \text{distance required.}$$

$$\begin{array}{r} 558 \cdot 6 \\ \hline \end{array}$$

$$\begin{array}{r} 4140 \\ 3990 \\ \hline \end{array}$$

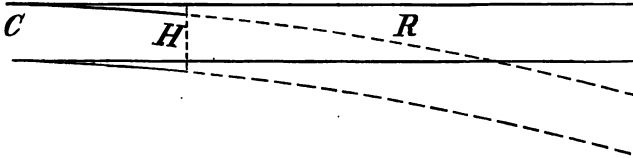
$$\begin{array}{r} 1500 \\ 798 \\ \hline \end{array}$$

$$\begin{array}{r} 7020 \\ 6384 \\ \hline \end{array}$$

$$\begin{array}{r} 634 \\ \hline \hline \end{array}$$

50.—To ascertain the distance from heel of switches to commencement of curve.

Figure 17.



D Distance.      ACCURATE.     $\sqrt{2 R - .37 \times .37} = \text{distance required.}$   
 R Radius.  
 O Offset.

EXAMPLE.

51.—Required the distance from heel of switches to commencement of curve, radius being 600 feet.

$$\begin{array}{r}
 600 \\
 2 \\
 \hline
 1200 \cdot \\
 \phantom{1200} \cdot 37 \\
 \hline
 1199 \cdot 63 \\
 \phantom{1199} \cdot 37 \\
 \hline
 839741 \\
 359889 \\
 \hline
 / 4 \cdot 43 \cdot 86 \cdot 31 (21 \cdot 06 \text{ distance required.} \\
 4 \\
 \hline
 41 \overline{) 43} \\
 \phantom{41} 41 \\
 \hline
 4206 \overline{) 28631} \\
 \phantom{4206} 25236 \\
 \hline
 \phantom{4206} 3395 \\
 \hline
 \hline
 \end{array}$$

52.—APPROXIMATE.       $\sqrt{2 R \times .37} = D.$

53.—EXAMPLE.

$$\begin{array}{r}
 600 \text{ radius.} \\
 2 \\
 \hline
 1200 \\
 \cdot 37 \\
 \hline
 8400 \\
 3600 \\
 \hline
 / 4.44.00 (21.07 = D. \\
 4 \\
 \hline
 41 \overline{)44} \\
 41 \\
 \hline
 4207 \overline{)30000} \\
 29449 \\
 \hline
 551 \\
 \hline
 \hline
 \end{array}$$

54.—Or, APPROXIMATE.  $2.64 \times I = \text{distance required}$ . Here 2.64 is a constant, and I is ratio of intersection.

## EXAMPLE.

55.—Required the distance from commencement of curve to heel of switches, radius being 600 feet.

Then ratio of intersection will be 7.98 (*See Article 33*);

$$\begin{array}{r}
 \text{And } 7.98 \\
 2.64 \\
 \hline
 31.92 \\
 478.8 \\
 1596 \\
 \hline
 \underline{\underline{21.0672}} \text{ distance required.}
 \end{array}$$

56.—To ascertain the distance of point of crossing from heel of switches.

$$\text{ACCURATE } \sqrt{2R - A \times A} - \sqrt{2R - 37 \times 37} = D.$$

## 57.—EXAMPLE.

Thus	600 radius.		600 radius.	
	2		2	
	<u>1200</u>		<u>1200</u>	
	·37		4·70	
	<u>1199·63</u>		<u>1195·30</u>	
	·37		4·70	
	<u>839741</u>		<u>8367100</u>	
	359889		478120	
	<u>443·1631(21·06</u>		<u>5617·9100(74·95</u>	
	4		49	
	<u>41)43</u>		<u>144)717</u>	
	41		576	
	<u>4206)28631</u>		<u>1489)14191</u>	Then 74·95
	25236		13401	21·06
	<u>3395</u>		<u>14985)79000</u>	<u>53·89 = D.</u>
			74925	
			<u>4075</u>	

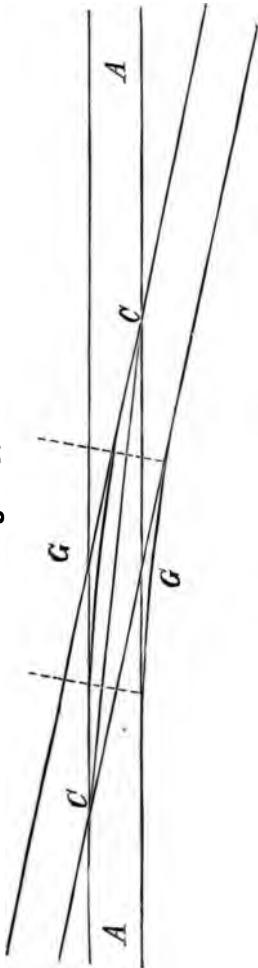
58.—(APPROXIMATE.) Multiply the constant 6·76 by the ratio of intersection, which will give the distance required.

## EXAMPLE.

59.—Required the distance from heel of switches to point of crossing, ratio of intersection being 1 in 8·00.

$$\begin{array}{r}
 \text{Then } 6\cdot76 \\
 \quad 8\cdot00 \\
 \hline
 54\cdot0800 = D. \\
 \hline
 \hline
 \end{array}$$

Figure 18.



60.—To construct a compound within the crossings, C C. (*See Fig. 18.*)

$\frac{R}{2I}$  = to distance from centre of elbow G to commencement of curve.

**EXAMPLE.**

61.—Required to construct a compound in a through crossing, angle 1 in 10·00, and radius required being 942 feet.

$$\begin{array}{rcl}
 10 \times 2 = 20 & 942 & (47 \cdot 1 \text{ distance from centre of} \\
 & 80 & \text{elbow to commence-} \\
 & \hline
 & 142 & \text{ment of curve.} \\
 & 140 & \\
 & \hline
 & 20 & \\
 & 20 & \\
 & \hline
 \end{array}$$

62.—To ascertain the distance from heel of switches to centre of elbow G, in constructing a compound within the crossings C C.

**APPROXIMATE.**  $2 \cdot 07 \times I$ .

Here 2·07 is a constant, and I is ratio of intersection of crossings C C and elbows G G.

**EXAMPLE.**

63.—Required the distance from centre of elbow to heel of switches in a compound, ratio of intersection being 1 in 10·00.

Then  $2 \cdot 07 \times 10 = 20 \cdot 7$  distance required.

64.—To ascertain the offset at any particular angle of intersection with a line parallel to the tangent line.

**APPROXIMATE.**  $\frac{R}{I^2 \times 2}$  = offset required.

## 65.—EXAMPLE.

Angle 7·98	127·36)60000(4·71
7·98	50944
<hr/>	<hr/>
6384	90560
7182	89152
<hr/>	<hr/>
5586	14080
<hr/>	<hr/>
6368·04	12736
2	<hr/>
<hr/>	1344
127·36	<hr/> <hr/>

66.—To ascertain the distance from commencement of curve to the point where any particular angle of intersection takes place.

$$\text{FORMULÆ. } \frac{R - \frac{1}{2} I.}{I}$$

## EXAMPLE.

67.—Required the distance from commencement of a curve 1·000' radius to the point where the angle of intersection is 1 in 8·00.

$$\begin{array}{r} \text{Radius } 1000' \\ \frac{1}{2} \text{ Angle of intersection } 4 \\ \hline \text{Angle of intersection } 8 \text{ ) } 996 \\ \hline 124\cdot5 \text{ distance required.} \\ \hline \hline \end{array}$$

68.—To ascertain the angle of crossing in degrees of the circle.

$$\frac{A}{R} = V.$$

Here A is Gauge of road.

„ R „ Radius.

„ V „ Versed sine of curvature.

## EXAMPLE.

69.—Required the angle of crossing in degrees of the circle, when A is = 4·70 and R 600'.

$$\frac{4\cdot70}{600} = \cdot007833 = 7^\circ\cdot10'.$$

70.—If two curves approach each other from two parallel lines (*See Figure 19*), they will meet at a point proportional to the arithmetical ratio of their radii; to ascertain which, take the sum of their radii, and divide the distance between the parallel lines by this sum; then multiply the quotient by each radius separately; the product will be the distance from the parallel lines to a parallel line which will run through the point of intersection.

NOTE.—The point of intersection will be as the large radius is, multiplied into the constant for the smaller radius, and *vice versa*. Then for the distance from the commencement of curve to point of intersection, see formulæ 44.

#### EXAMPLE.

71.—Let two curves approach each other from two parallel lines, their radii being 1200 and 800 feet respectively, and the distance between the parallel lines being 6.20. Required the distance from starting point to point of intersection.

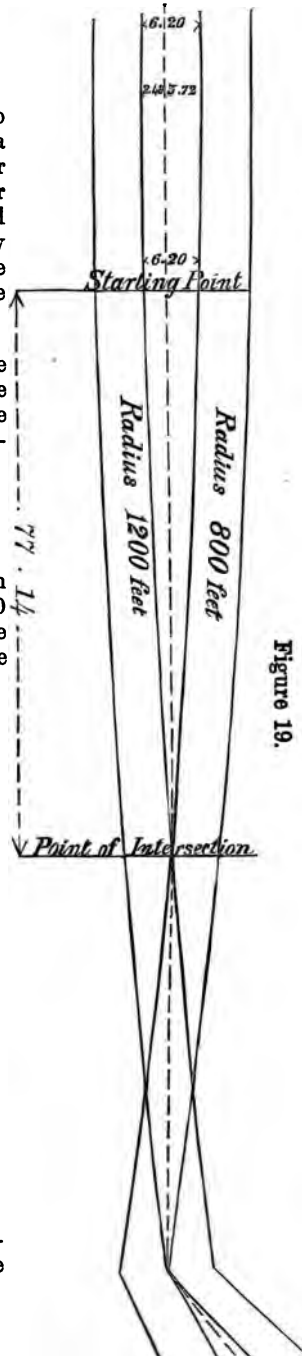
$$\frac{2000 \cdot 6.20 \cdot .0031}{6000}$$

$$\frac{2000}{2000}$$

Then .0031	.0031
1200	800
3.7200	2.4800
1600	2400
22320000	9920000
37200	49600
59.52.0000	59.52.0000

$$\text{Then } \sqrt{59.52.00.00} = 77.14 = D.$$

72.—77.14 distance of intersection from commencement of curve, and 3.72 and 2.48 being the distance of centre of intersection from parallel line.



## MEMORANDA.

73.—If two rails approach each other back to back, the intersection will require an acute-angled crossing, technically termed a crossing.

74.—If two rails approach each other, the back of one rail approaching the face of the other, the intersection will require an obtuse-angle crossing, technically termed an elbow, or angle.

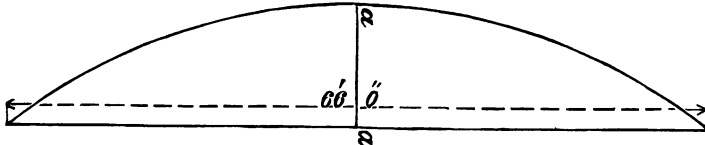
75.—The opening at heel of switches is taken throughout this work as  $\cdot 37$ ; and the opening at heel of switches being  $\cdot 37$ , the heel of switches should be fixed in the line, at that point, on the curve, where the offset is  $\cdot 37$ .

76.—The crossing should be always fixed at the proper "lead," *i.e.*, the right distance from heel of switches, required by the particular ratio of intersection, and the curve between switches and crossing, set out by the proper offsets. The "lead" will be the same for the same angle of intersection whether the main line is straight or curved.

77.—In compounds, and through crossings, the distance from elbows to crossings is as the ratio of intersection multiplied by gauge of road.

78.—Practical rule for ascertaining the proper superelevation of the outer rail of curves. The superelevation should be equal to the versed sine A A on a 66 feet chord.

Figure 20.



THROUGH CROSSING, WITH COMPOUND.

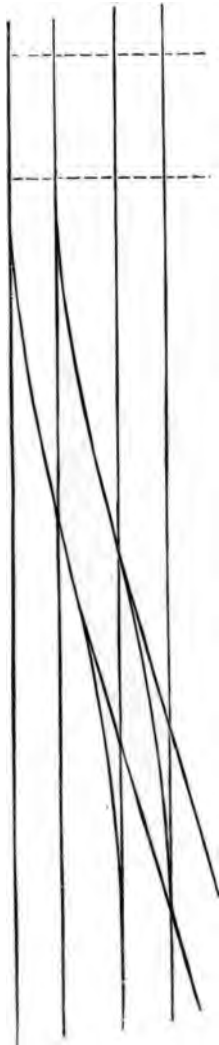


Figure 21.

DOUBLE JUNCTION.

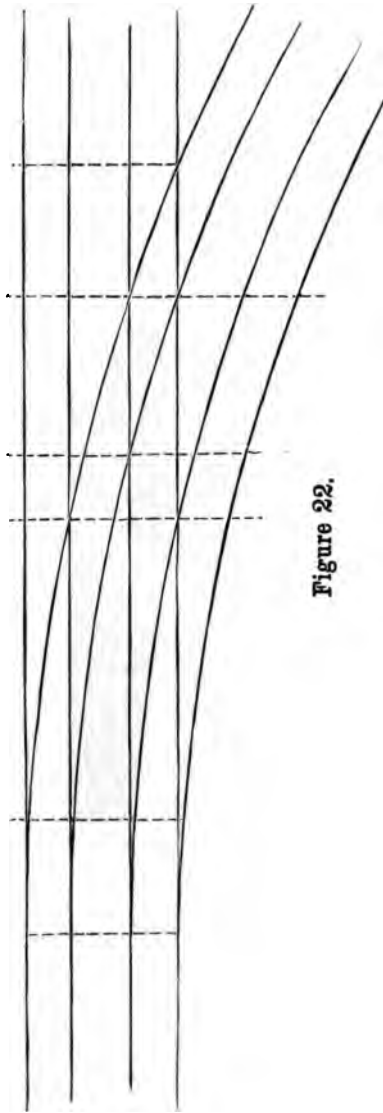


Figure 22.

				ARTICLE
Examples for working Formulæ, see article next after each Formulæ.				
Formulæ for calculating Offsets in Minutes of the Circle .....				4
"	"	Degrees of the Circle .....		6
"	"	Measurements, Accurate.....		12
"	"	" " " " " " .....		14
"	"	Connecting two Lines by a Curve .....		16
"	"	" " by a Curve of given Radius.....		17
"	"	" " " " " " .....		18, 19
"	"	Setting out Curves from the Chord .....		21
"	"	Offsets, Approximate .....	23, 25, 27,	29
"	"	Measuring Ratio of Intersection on the Ground .....		31
"	"	Ratio of Intersections, Accurate .....	32, 34,	38
"	"	" " Approximate .....		36, 40
"	"	Point of Intersection from commencement of Curve, Accurate		42
"	"	" " from commencement of Curve, } Approximate }	44, 46,	48
"	"	Distance from heel of Switches to commencement of Curve ..		40
"	"	" " " " " " Approximate		52
"	"	" " " " " " " "		54
"	"	" Point of Crossing to heel of Switches .....		56
"	"	" " " " " " Approximate		58
"	"	To construct a Compound within Crossings.....		60
"	"	Distance of heel of Switches from centre of Elbows .....		62
"	"	Offset at any particular angle of intersection .....		64
"	"	Distance from centre of Curve to any particular angle .....		66
"	"	Angle of Crossing in Degrees of the Circle .....		68
"	"	Ratio of Curves approaching each other .....		70
Memoranda .....				73, 74, 75, 76, 77, 78
Offsets proportioned to Tangents.....				11
Properties of the Circle applicable to setting out Railway Curves.—Figure 1.				
Ranging Curves with Poles .....				9, 10
Theodolite, use of, in ranging Curves .....				1, 2, 3, 4, 5, 6, 7, 8

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